



Identification of a ~ 500 ms isomer in ^{67}Co through $\beta\gamma$ correlations

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Nuclear Structure around semi-doubly magic ^{68}Ni

$$^{68}\text{Ni} \otimes (\nu^{-1} \pi^{+1})$$

$$\begin{array}{l} \pi p_{1/2} \nu p_{1/2}^{-1} \quad \underline{1+} \quad \underline{842} \\ \quad \quad \quad \underline{2+} \quad \underline{84} \\ \pi p_{3/2} \nu p_{1/2}^{-1} \quad \underline{1+} \quad \underline{0} \end{array}$$

S. Franchoo Ph.D. Thesis, Leuven 1999

$$^{68}\text{Ni} \otimes (\pi^{+1})$$

$$\begin{array}{l} \pi g_{9/2} \quad \underline{9/2+} \quad \underline{2553} \\ \pi f_{5/2} \quad \underline{5/2-} \quad \underline{1214} \\ \pi p_{1/2} \quad \underline{1/2-} \quad \underline{1110} \\ \pi p_{3/2} \quad \underline{3/2-} \quad \underline{0} \end{array}$$

J. Van Roosbroeck, Phys.Rev.C 69 2004

$$^{68}\text{Ni} \otimes (\nu^{+1} \pi^{+1})$$

$$\begin{array}{l} \pi g_{9/2} \nu g_{9/2} \quad \underline{1+} \quad \underline{1980} \\ \pi f_{5/2} \nu g_{9/2} \quad \underline{2-} \quad \underline{369} \\ \pi p_{3/2} \nu p_{1/2}^{-1} \quad \underline{1+} \quad \underline{242} \\ \quad (\nu g_{9/2})^{+2} \quad \underline{6-} \quad \underline{0} \\ \pi p_{3/2} \nu g_{9/2} \end{array}$$

J. Van Roosbroeck, Phys.Rev.C 69 2004

$$^{68}\text{Ni} \otimes \nu^{-1}$$

$$\begin{array}{l} \nu g_{9/2} \quad \underline{9/2+} \quad \underline{1007} \\ (\nu p_{1/2})^{-2} \quad \underline{5/2-} \quad \underline{694} \\ \nu f_{5/2}^{-1} \quad \underline{1/2-} \quad \underline{0} \\ \nu p_{1/2}^{-1} \end{array}$$

L. Weissman, Phys.Rev.C 59 1999

$$^{68}\text{Ni} \otimes \nu^{+1}$$

$$\begin{array}{l} \nu p_{3/2}^{-1} \quad \underline{3/2-} \quad \underline{1400} \\ (\nu g_{9/2})^{+2} \quad \underline{5/2-} \quad \underline{915} \\ \nu f_{5/2}^{-1} \quad \underline{1/2-} \quad \underline{321} \\ (\nu g_{9/2})^{+2} \quad \underline{9/2+} \quad \underline{0} \\ \nu g_{9/2} \end{array}$$

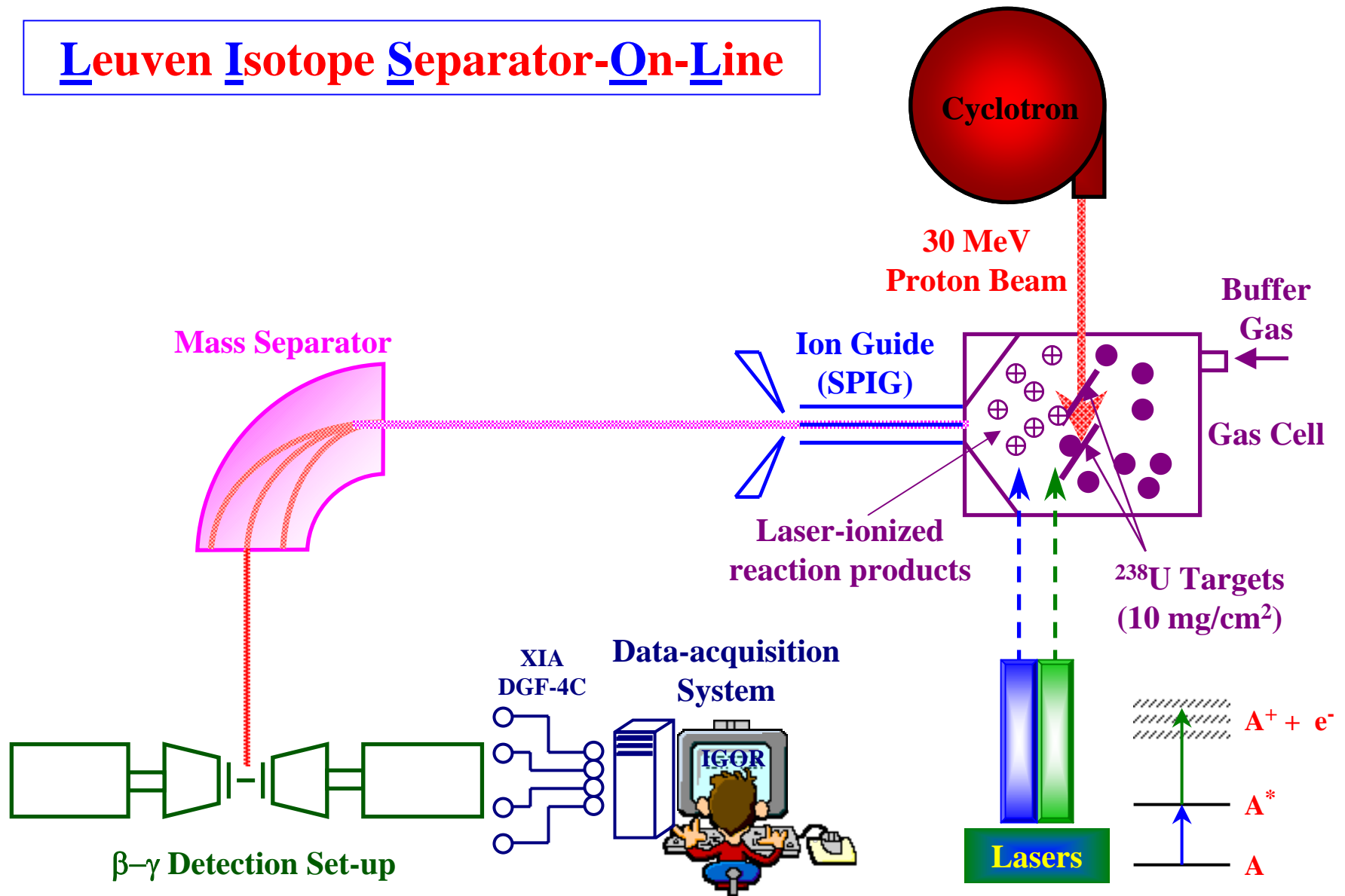
W.F. Mueller, Phys.Rev.Lett. 83, 1999

	^{68}Cu	^{69}Cu	^{70}Cu	π^{+1}
	^{67}Ni	^{68}Ni	^{69}Ni	$Z=28$
^{65}Co	^{66}Co	^{67}Co	^{68}Co	π^{-1}
	^{65}Fe	^{66}Fe	^{67}Fe	^{68}Fe

Almost nothing is known about nuclear structure of $^{65,66,67,68}\text{Co}$

Experimental set-up

Leuven Isotope Separator-On-Line

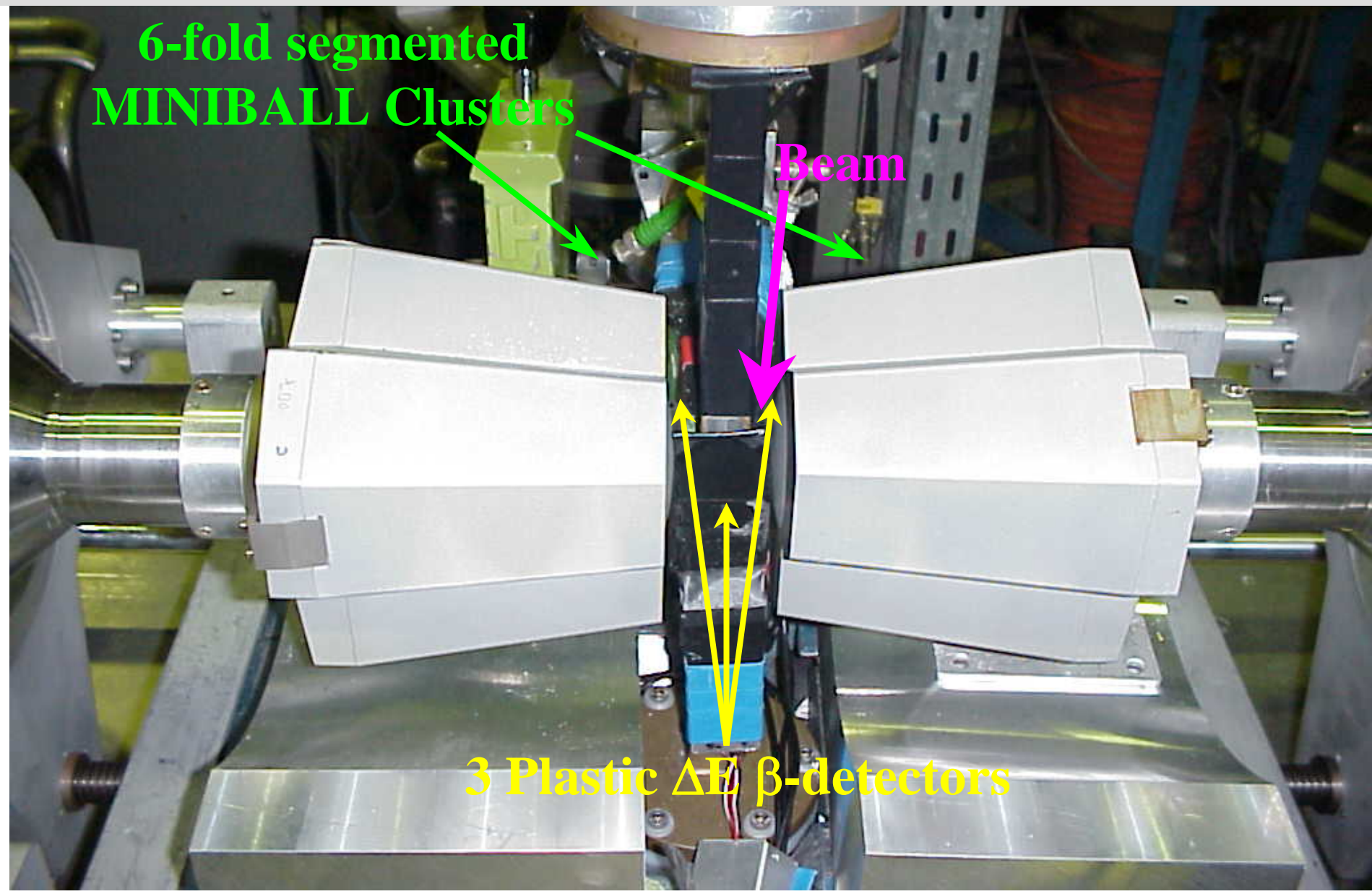


Detection set-up

6-fold segmented
MINIBALL Clusters

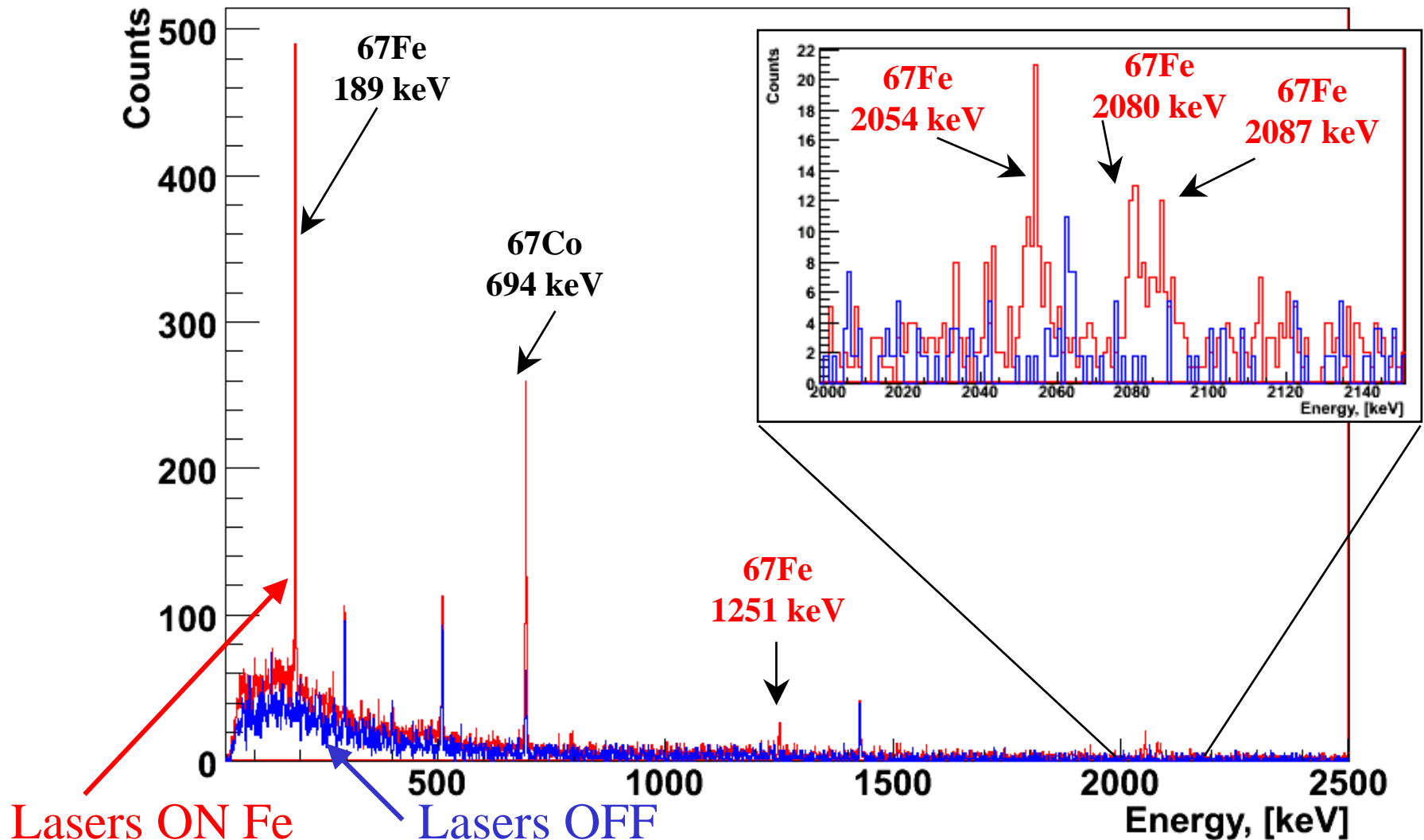
Beam

3 Plastic ΔE β -detectors



Analysis of β -gated γ events (data 2005)

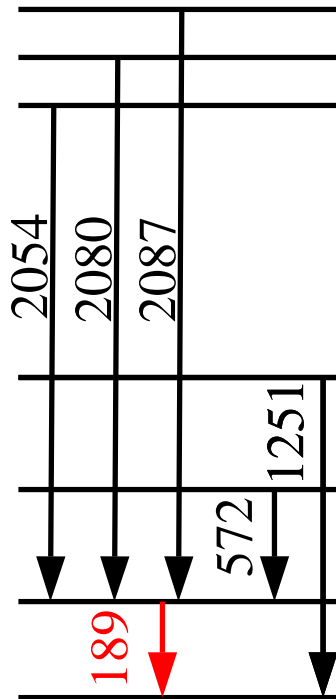
^{67}Fe : beta-gated, 1,5s/1,5s/3c, Laser ON / OFF - RED / BLUE (1 : 1.82), All Cores, All Files



^{67}Fe decay scheme after $\beta\gamma$ analysis

$T_{1/2}=395(30)$ ms

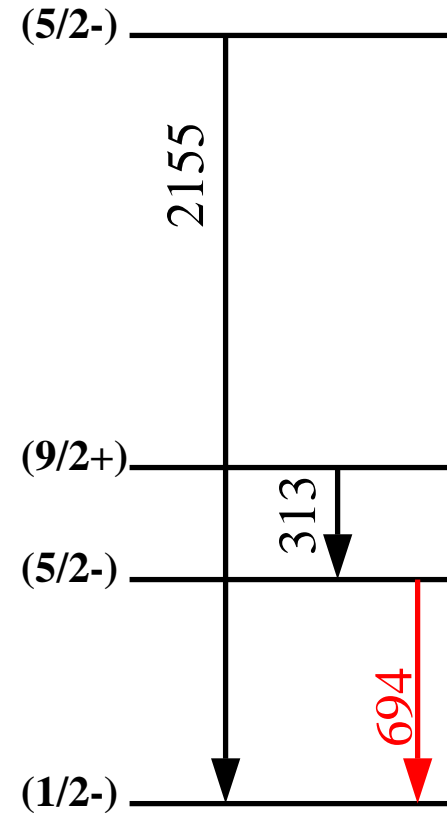
^{67}Fe β^-



^{67}Co

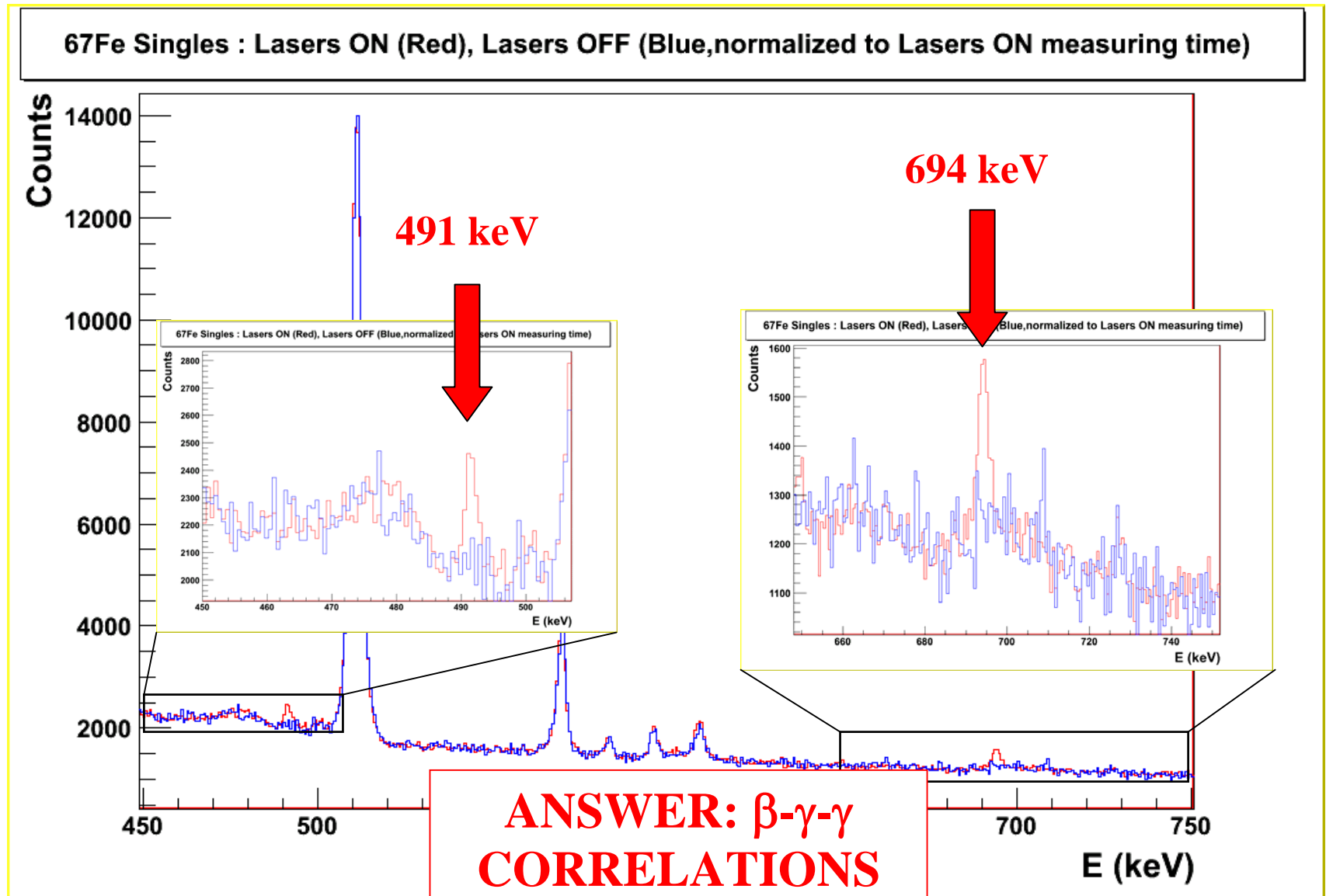
$T_{1/2}=425(20)$ ms

^{67}Co β^-

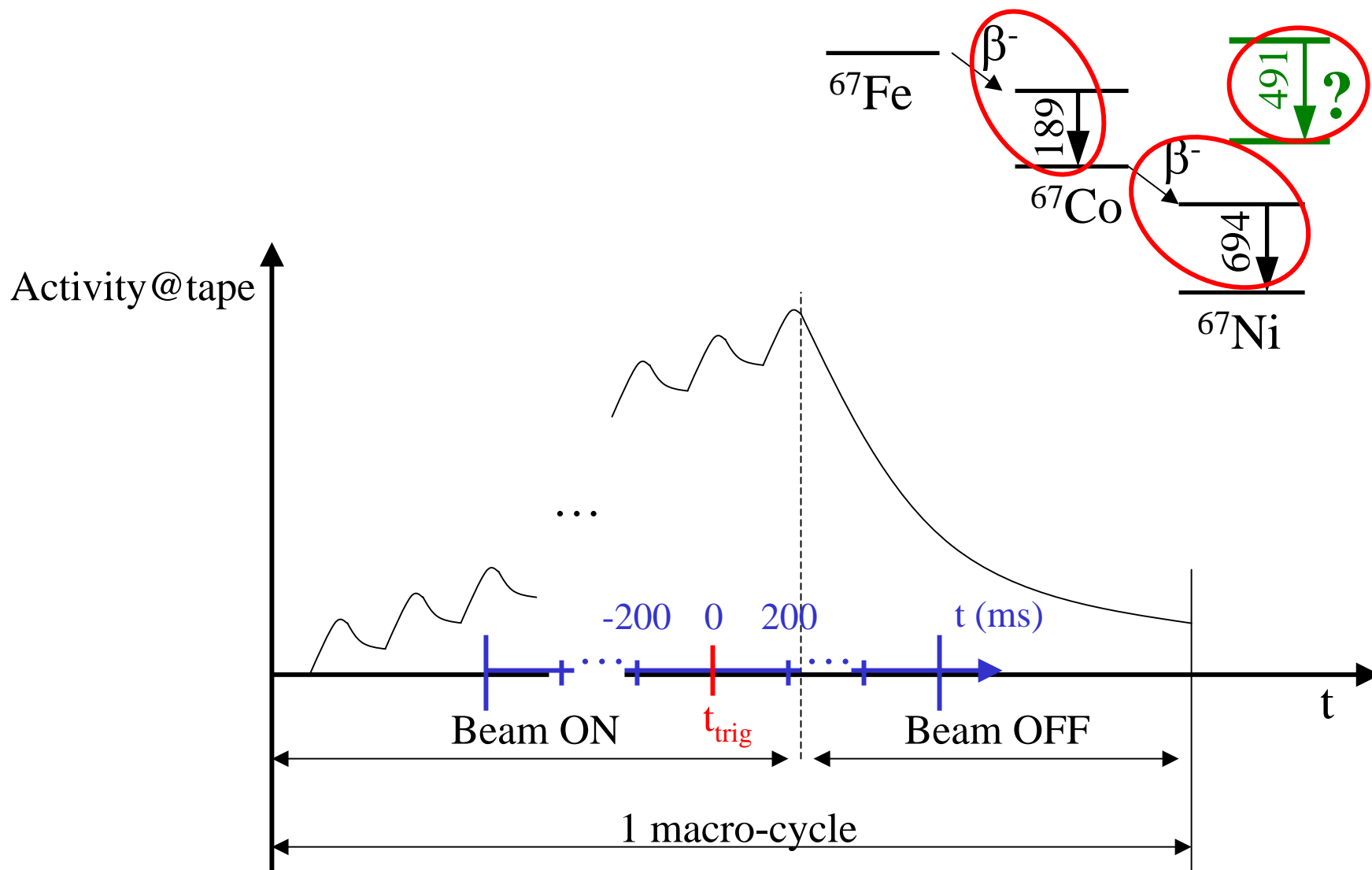


^{67}Ni

Single γ spectrum: welcome 491 keV! (data 2005)

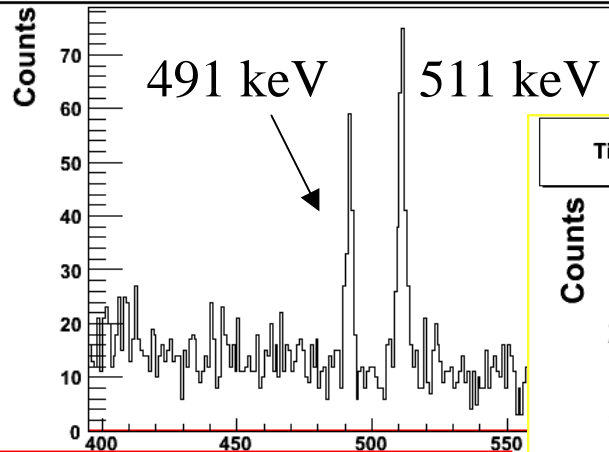


Cycle structure LISOL and Correlations (data 2006)



Result: single γ 's before (-200 – 0 ms) a β -694 keV trigger

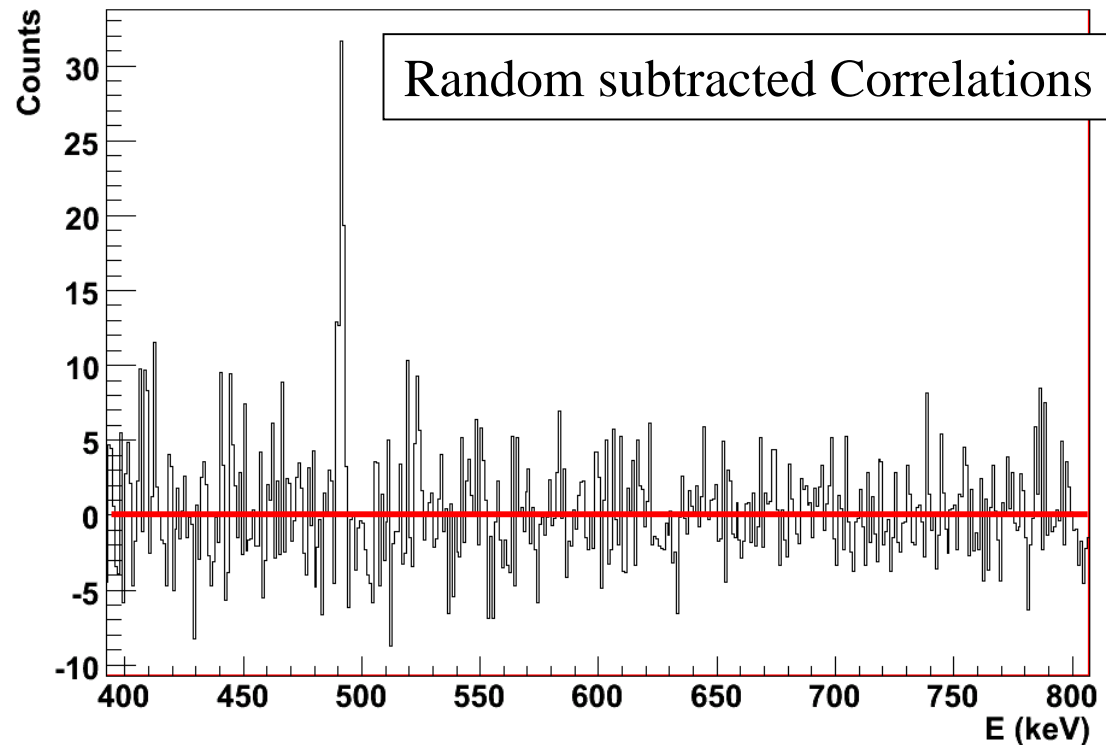
Time Slice #1: The β -694(± 3) keV Single γ Correlated Events within the time window [-200,0][ms]



Correlated events

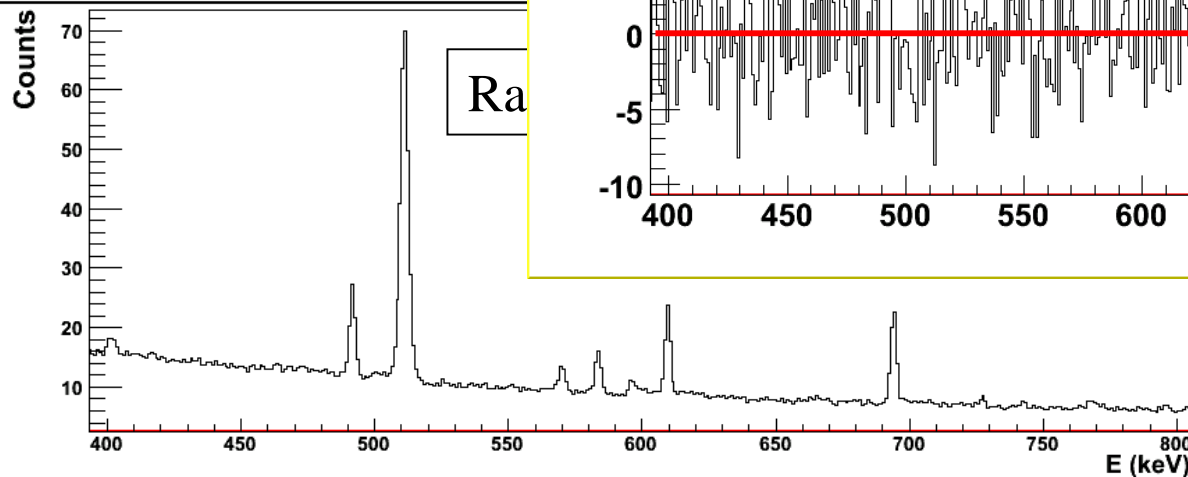
Control random events!

Time Slice #1: The β -694(± 3) keV Single γ Events Random Subtracted within the time window [-200,0][ms]



Random subtracted Correlations

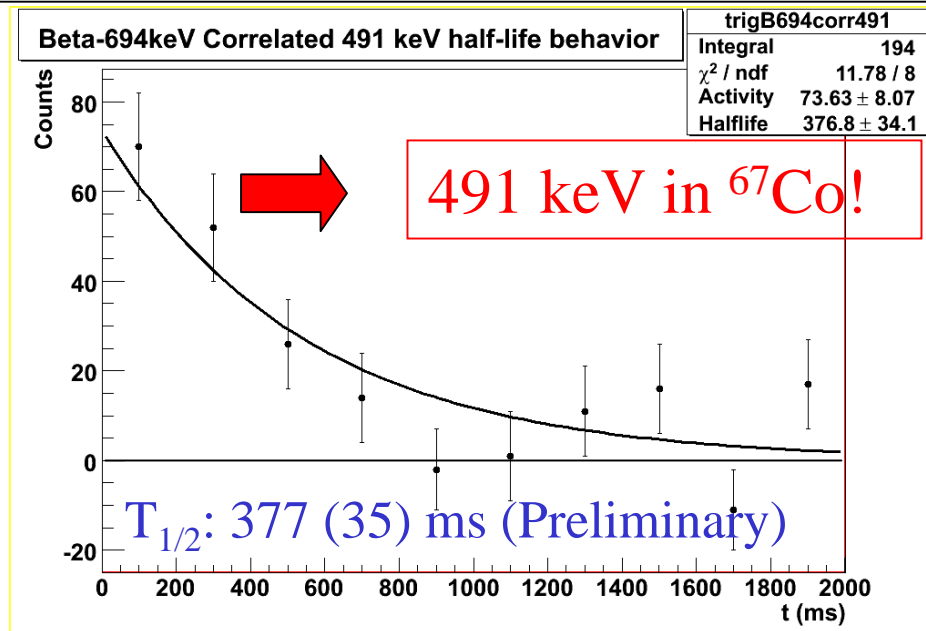
Time Slice #1: The β -694(± 3) keV Single γ Events



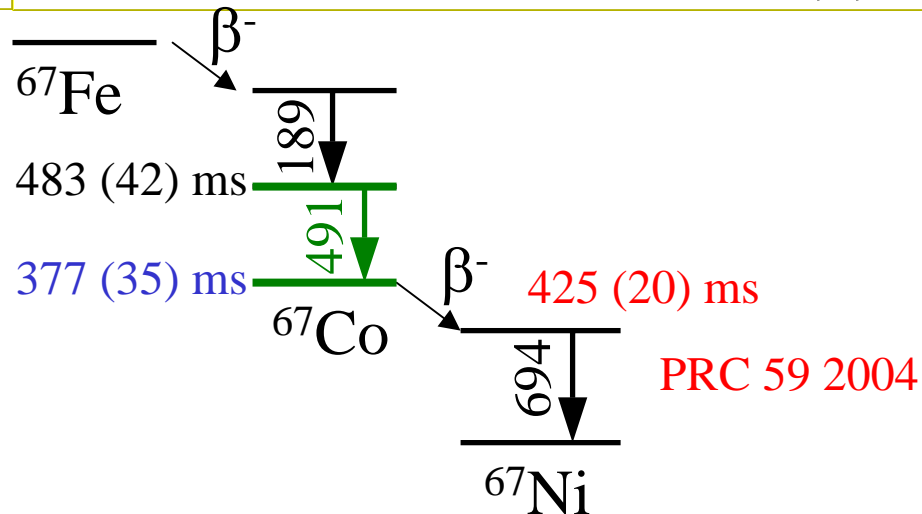
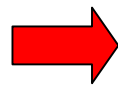
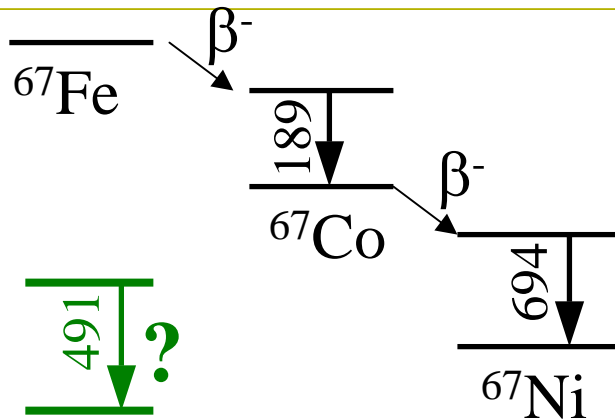
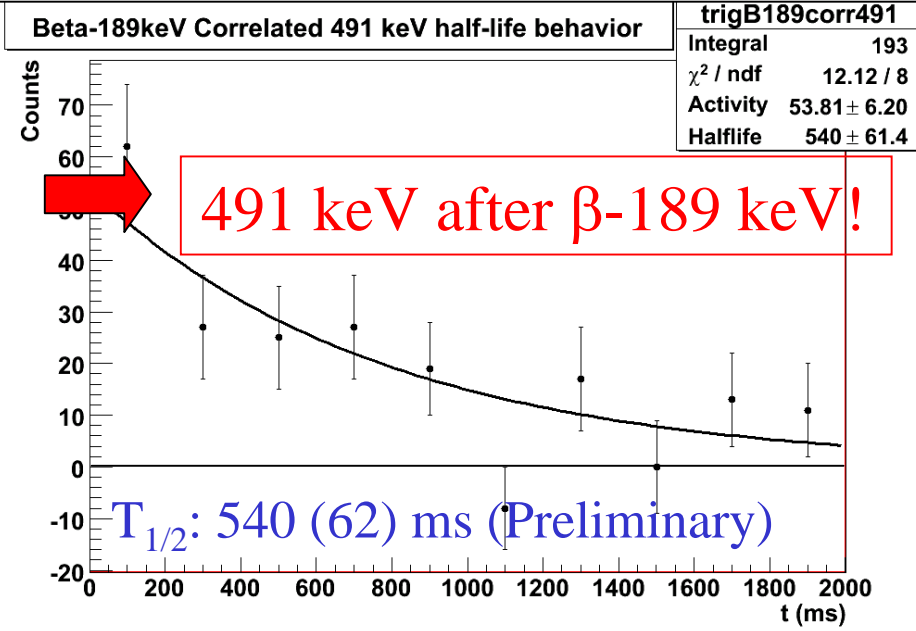
Ra

Random subtracted results

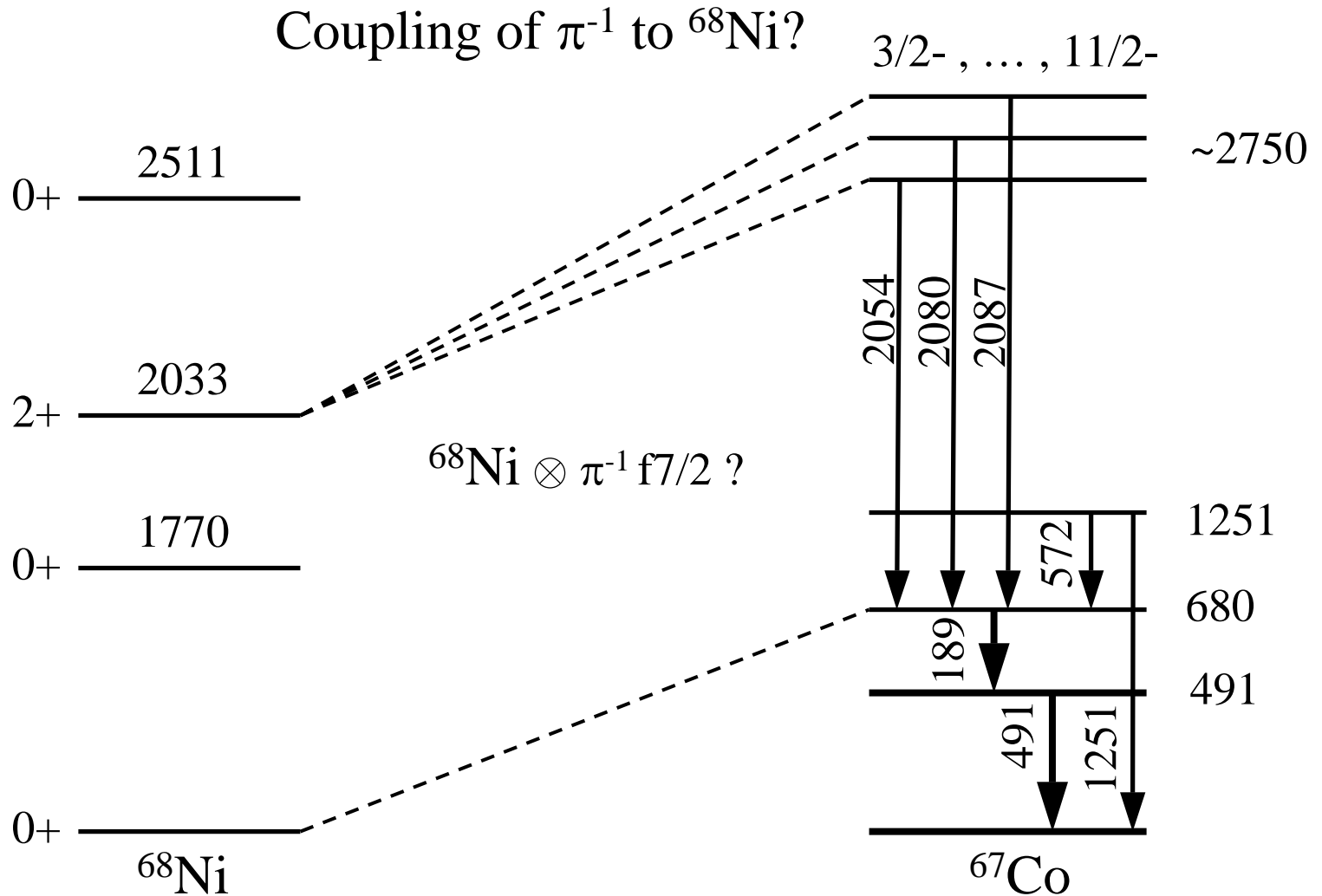
491 keV events coming before β -694 keV



491 keV events coming after β -189 keV



Interpretation ^{67}Co

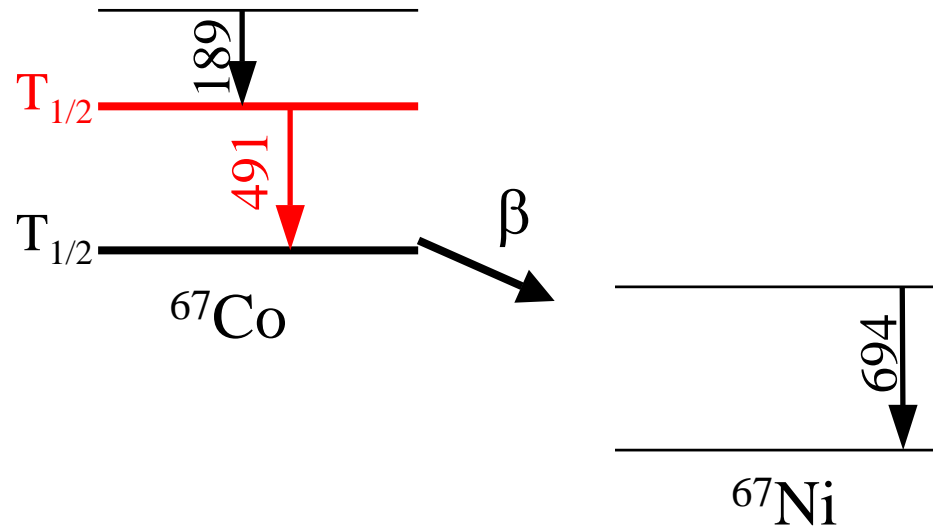


To explain ^{67}Co structure also collective effects have to be included!!

Conclusion

1. Thanks to correlations:

- Placing of the 491 keV isomer
- Preliminary $T_{1/2}$ g.s. ^{67}Co



2. Limitations (in this case):

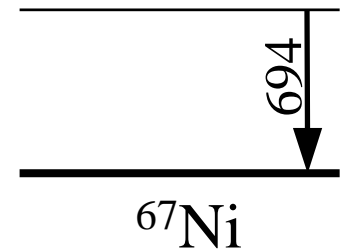
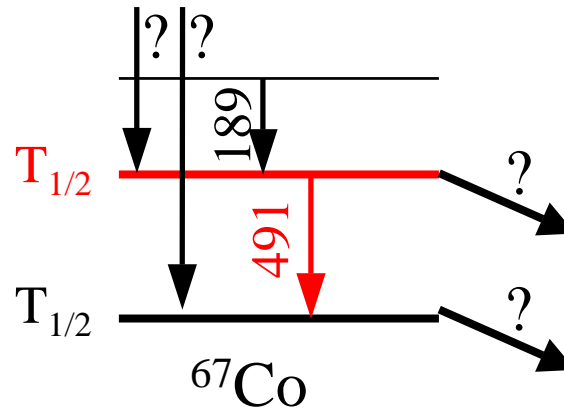
- $T_{1/2} > \sim 4$ s : effect too small

3. FIRST time this kind of β - γ - γ correlations!

Outlook

- Optimizing randoms => Half lives

=> Branching ratios



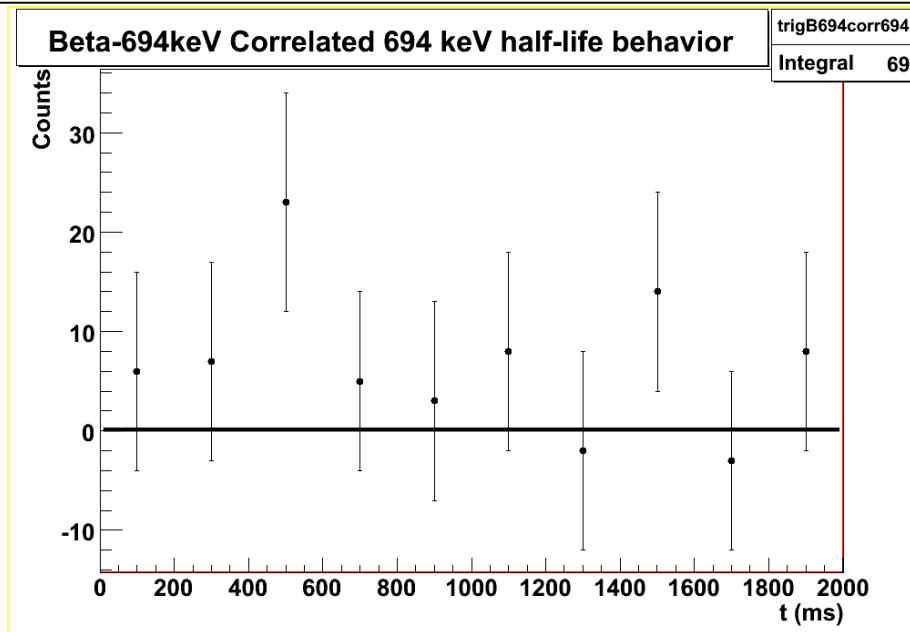
- Enhancing 491 keV sensitivity by using segmentation of MINIBALL cluster

Allowing only multiplicity 1 segment events

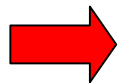
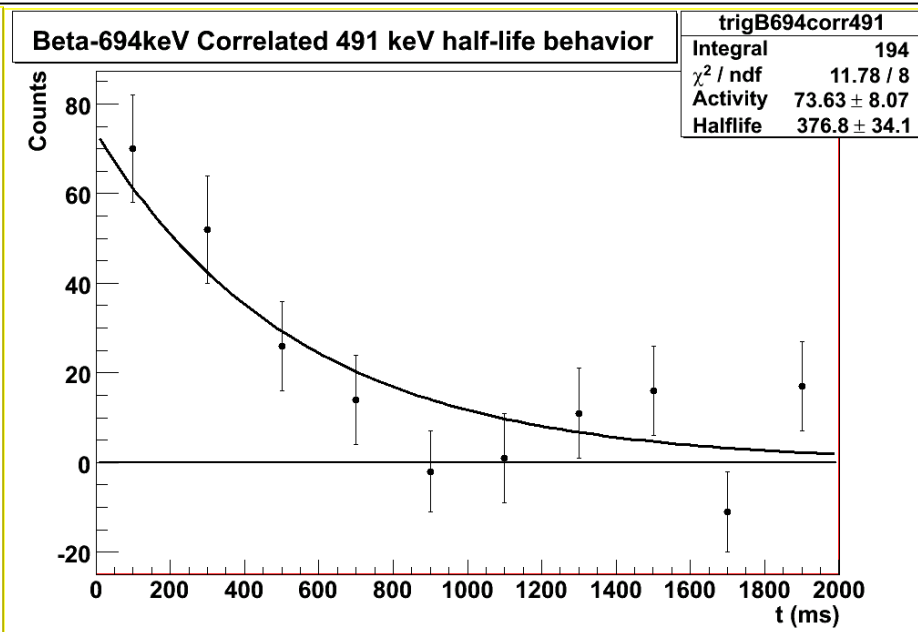
- New beam time @ LISOL is granted for a $^{64-66}\text{Fe}$ β -decay campaign in 2007: onset of deformation?

Random subtracted results

694 keV events coming before β -694 keV



491 keV events coming before β -694 keV



No correlation!



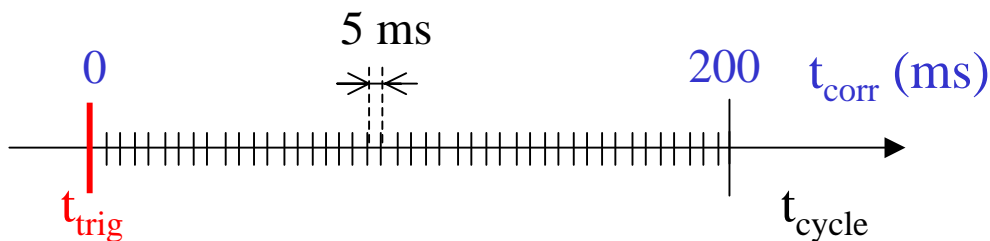
Correlation!

Randoms (in 1st order): strategy

Step 1: A dataset of single γ , β and β - γ histograms H_i in steps of 5 ms.

Step 2: Scan the trigger distribution in steps of 5 ms to know the number of triggers N_{tr} .

Step 3: Build the random $(\beta\text{-})\gamma$'s from the dataset and normalize to N_{tr} .



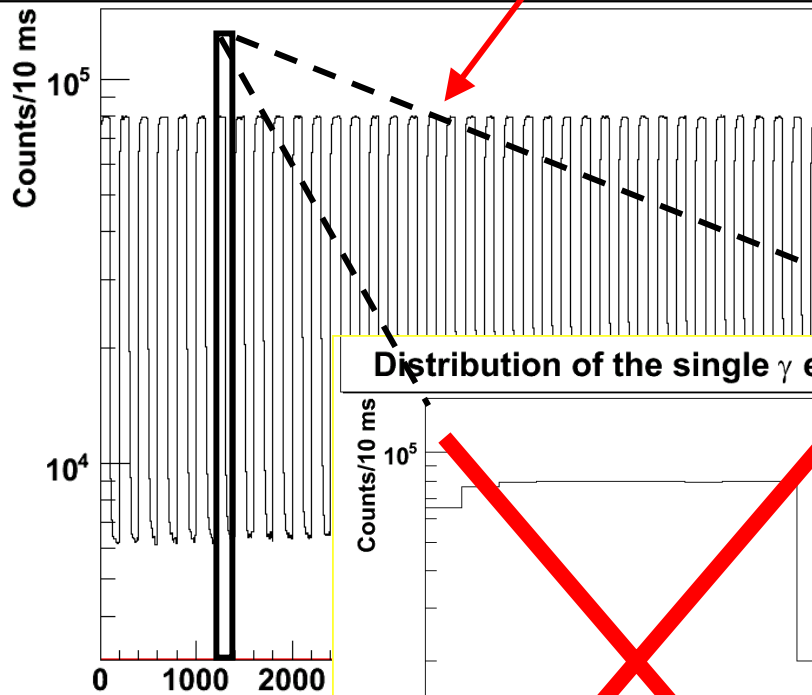
$$H_i^{norm} = \frac{H_i}{t_{random}} t_{corr}$$
$$\begin{cases} t_{corr} = N_{tr} * 5 \text{ ms} \\ t_{random} = \Delta t_{meas} / t_{cycle} * 5 \text{ ms} \end{cases}$$

Neutron-induced background (data 2006)

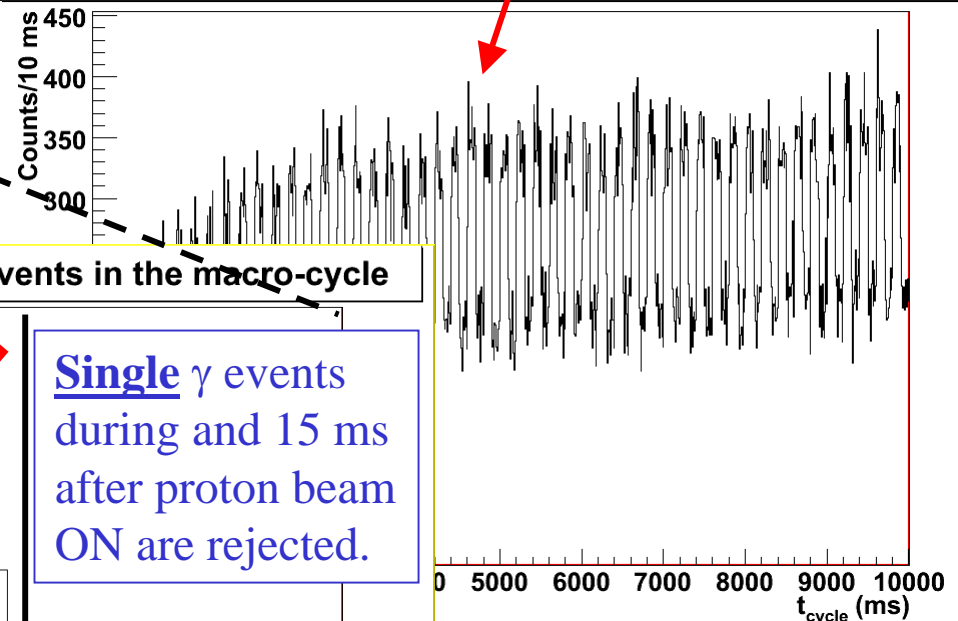
Macro-cycle: 10s/0s/1 Micro-cycle: 100ms/100ms

Neutron-induced events during the proton beam ON!

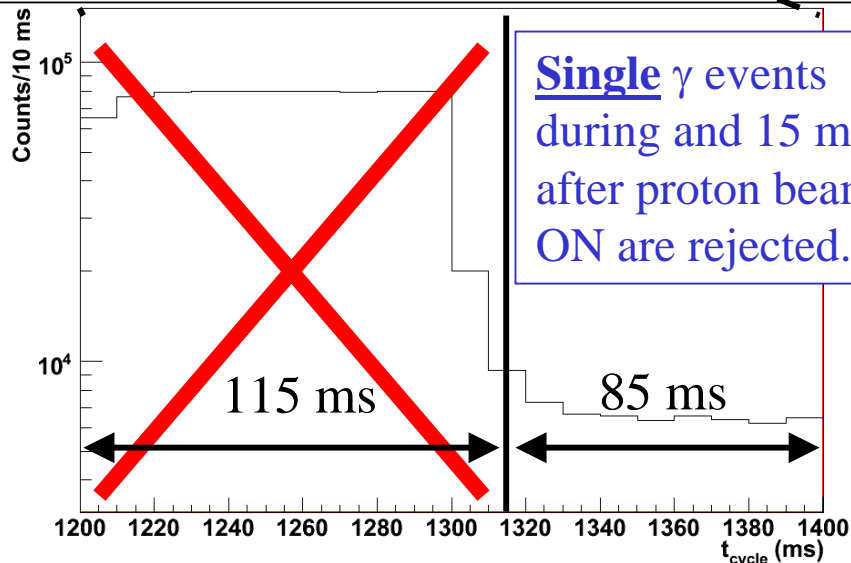
Distribution of the single γ events in the macro-cycle



Distribution of the β -gated γ events in the macro-cycle

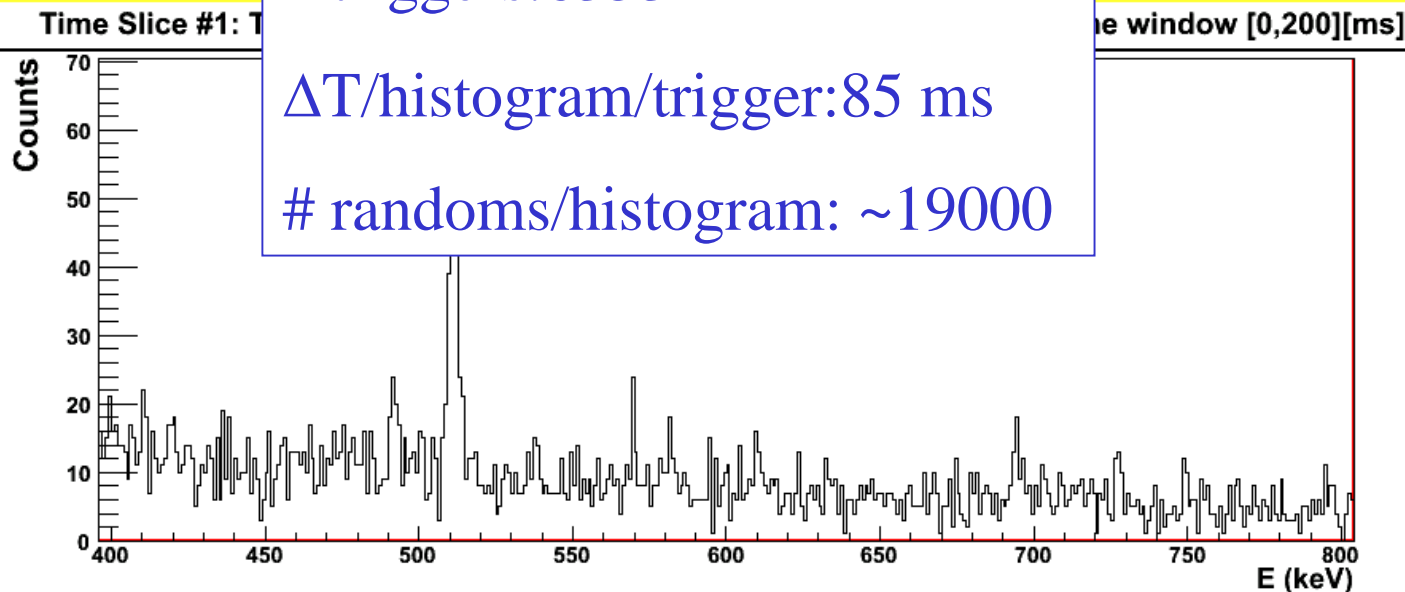
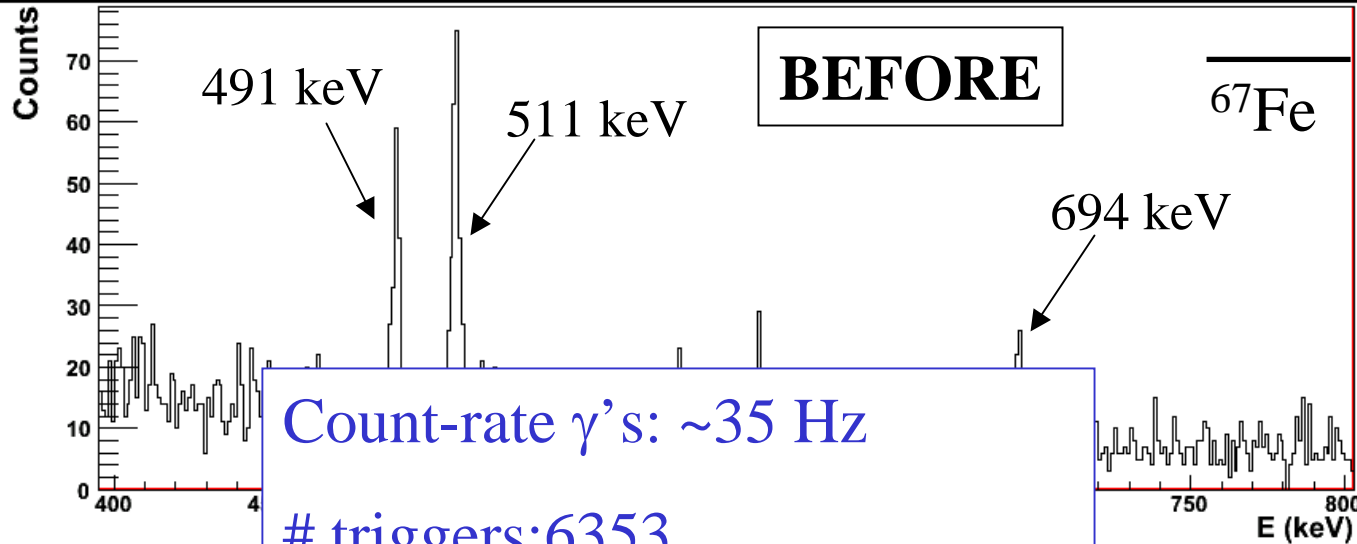


Distribution of the single γ events in the macro-cycle



Result: e.g. single γ 's before (-200 – 0 ms) or after (0 - 200 ms) a β -694 keV trigger

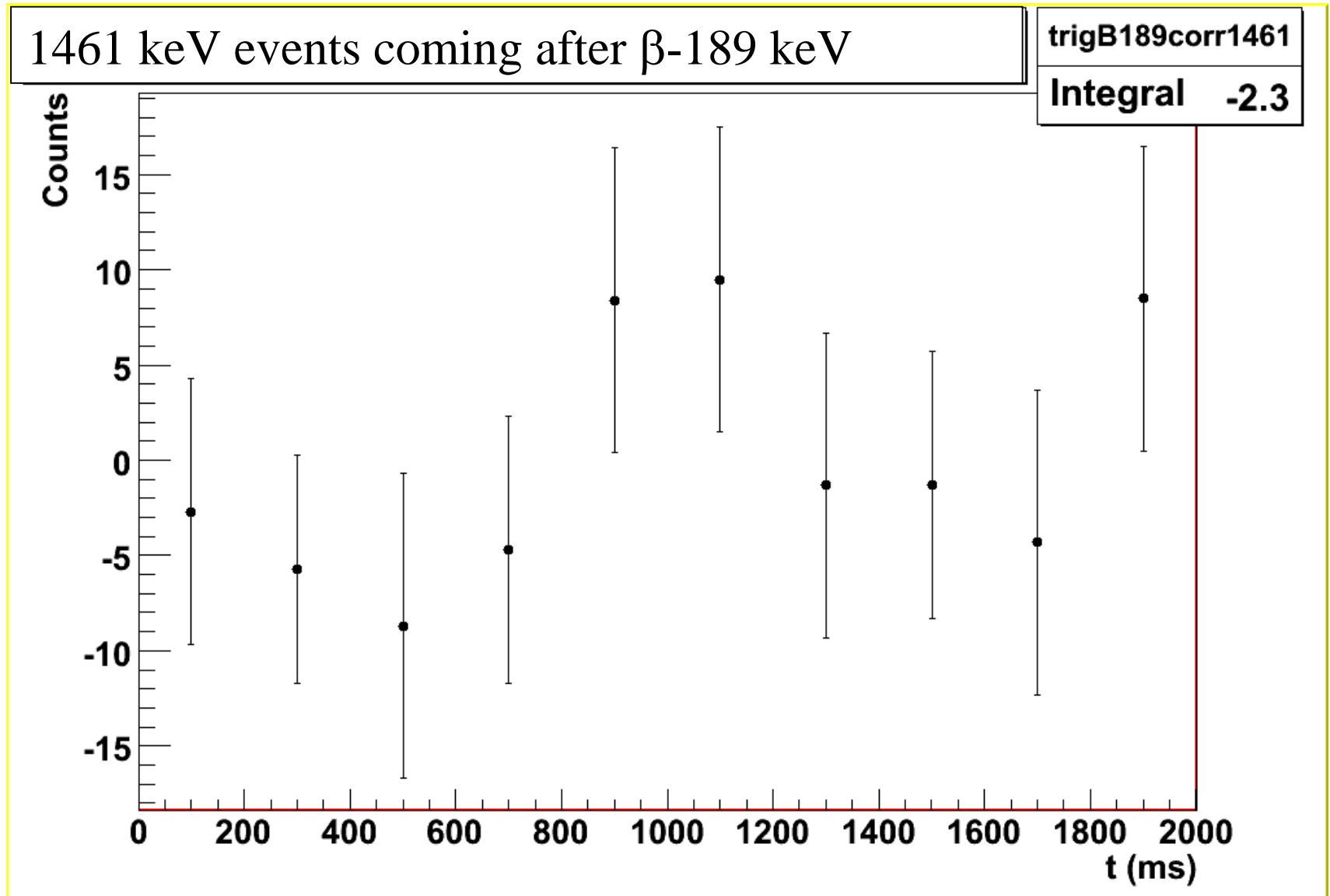
Time Slice #1: The β -694(± 3) keV Single γ Correlated Events within the time window [-200,0][ms]



491 ?

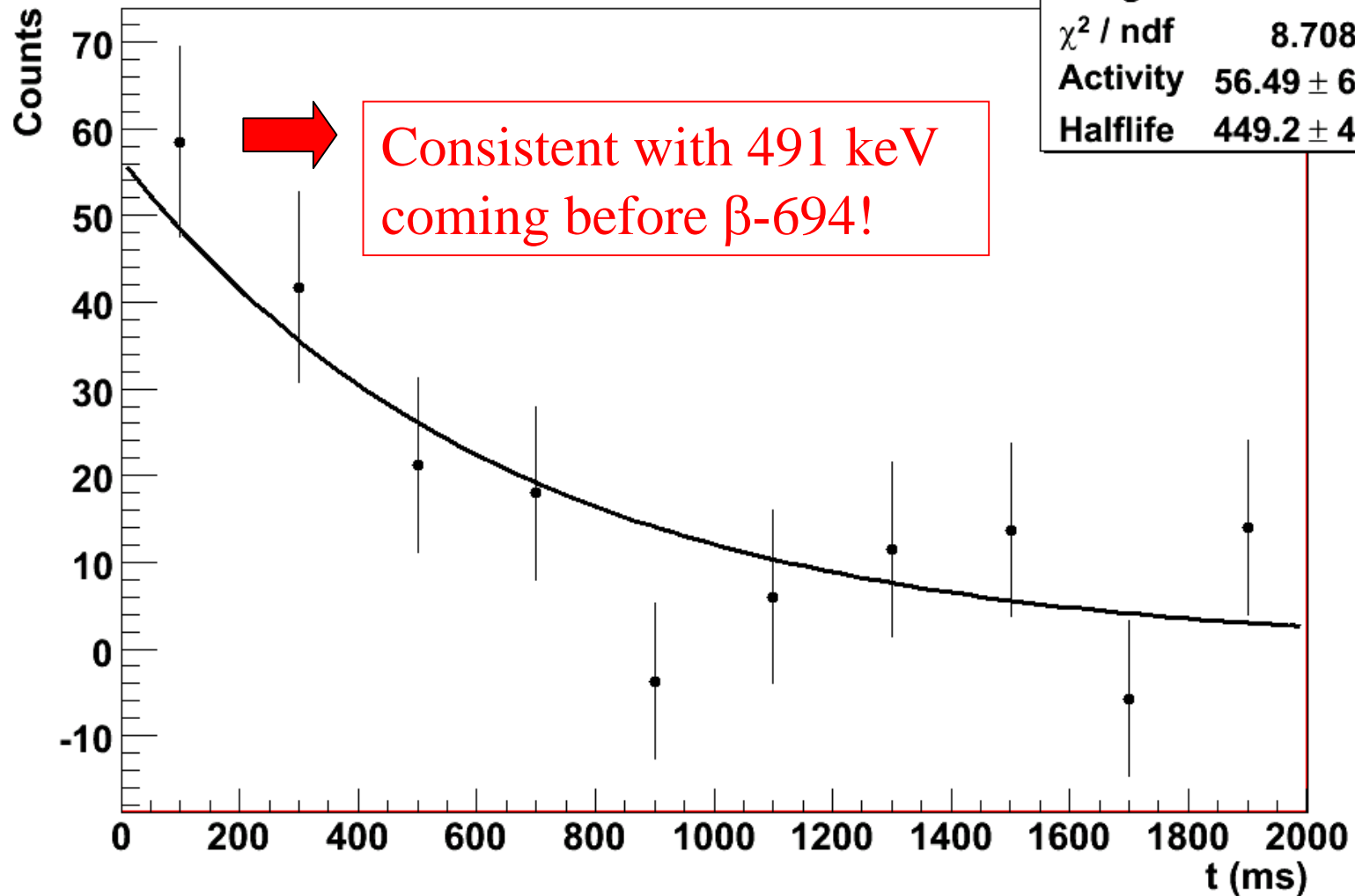
In ^{67}Co !!

Random subtracted results



Random subtracted results

β -694 keV events coming after 491 keV



Random subtracted results

β -189 keV events coming before 491 keV

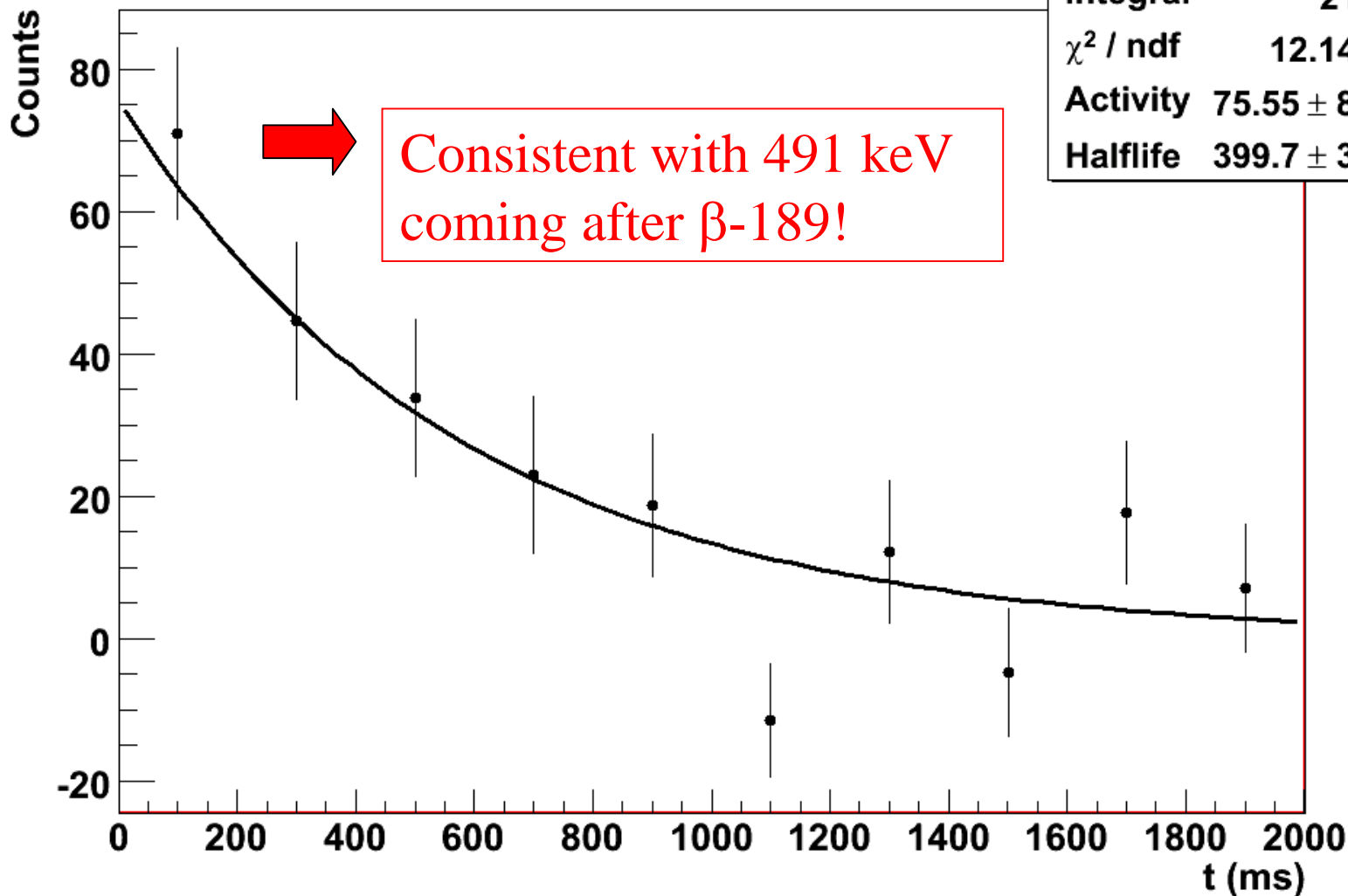
trig491corrB189

Integral 211.7

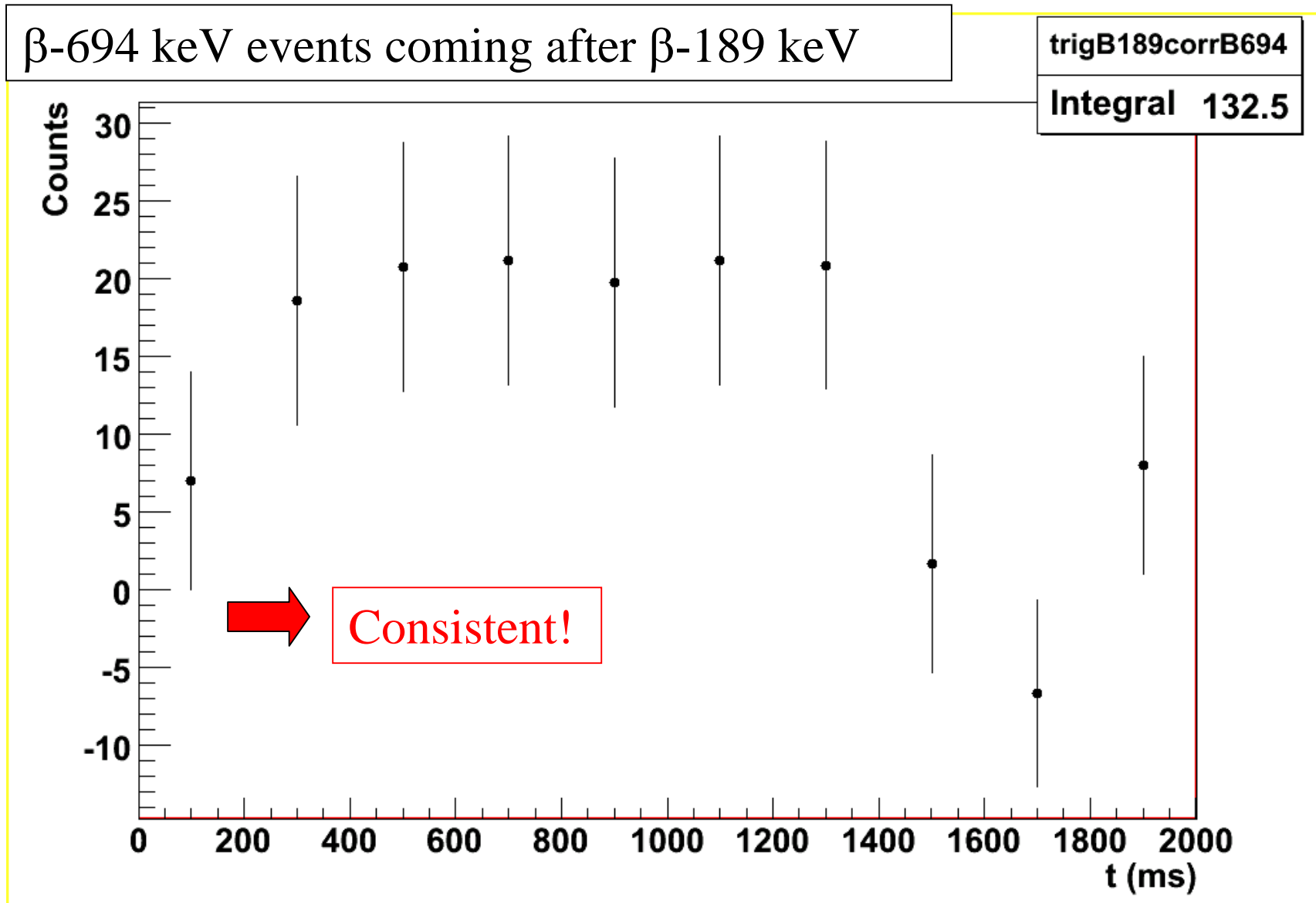
χ^2 / ndf 12.14 / 8

Activity 75.55 ± 8.02

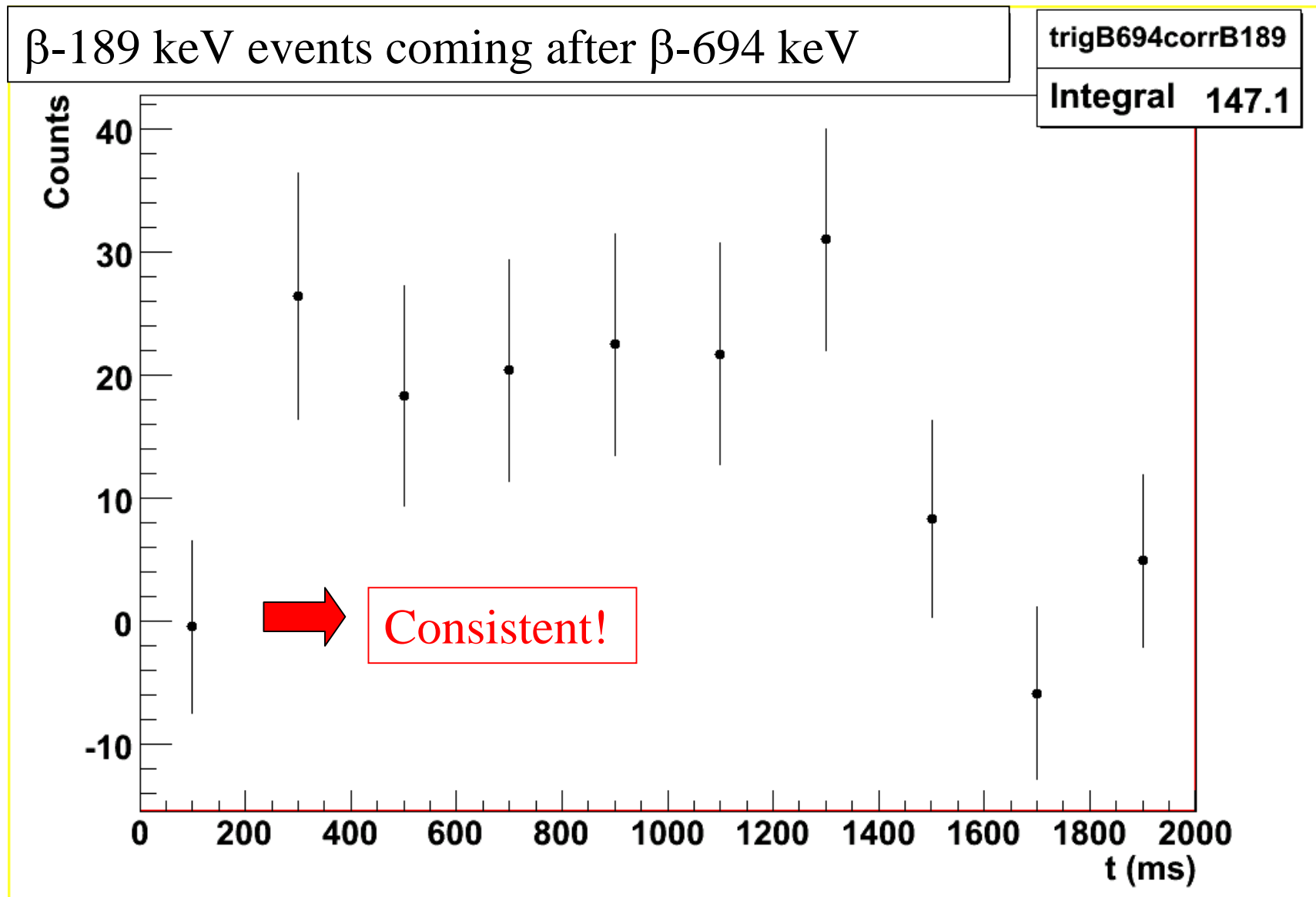
Half-life 399.7 ± 35.9



Random subtracted results



Random subtracted results



^{67}Fe situated on the chart of nuclides

